

1 **“SYSTEM AND PROCESS FOR CLIENT-DRIVEN**
2 **AUTOMATED COMPUTER-AIDED DRAFTING”**

3
4 FIELD OF THE INVENTION

5 The invention relates to a system for receiving a raw drawing,
6 implementing an adaptive rule-based process, and forming a detailed computer-
7 aided-drafting (CAD) drawing, the content of which complies with regulatory and
8 client criteria. More particularly, a remote client, through digital media, internet or
9 other electronic communication supplies raw architectural drawings and receives
10 detailed engineering drawings in return.

11
12 BACKGROUND OF THE INVENTION

13 In one context, a building design, in the form of architectural drawings
14 (preliminary drawings), is provided to an engineer or design professional who
15 applies codes, standards and rules to prepare and adjust the building design as
16 necessary to ensure regulatory compliance and to meet the client's individual
17 requirements. During this process, the design professional generates sufficient
18 detail for the production of detailed engineering drawings and specifications suitable
19 for construction including, for example, the location and type of electrical services
20 and heating, ventilating and air conditioning (HVAC), all of which are subject to
21 regulatory or higher design criteria. The detailed drawings are usually done by a
22 team of skilled draftspersons, who may also be design professionals. These
23 professionals also inject individuality and further detail into the final design.

1 An example of such a process is the generation of detailed
2 mechanical and electrical drawings which include: specifications for supports, stud
3 spacing and the position, number and capacity of electrical services, all of which are
4 substantially compatible with a raw architectural preliminary layout specifying walls,
5 doors, window layouts, and an elevation.

6 The drawing process, from architectural to detailed design drawings,
7 is generally conducted along the following lines. Draftspersons start with a base
8 plan, preferably extracted from an original raw architectural drawing. Alternatively,
9 the draftsman will draw the base plan from scratch. The designer, and more
10 often a plurality of designers, reviews the specifications for the type of structure
11 being designed. General specifications, including those required under the various
12 codes for the jurisdiction, are gathered and applied including: providing a minimum
13 wall insulation rating which sets minimum wall thickness, the form of electrical
14 services which determines the size and locations of the motor control centers, and
15 foundation backfill requirements including weeping tile and gravel filter
16 requirements. The client's own specifications are consulted and applied for
17 enhancing the design beyond those resulting from mere application of the general
18 specifications. The application of the specifications is rendered into detailed design
19 drawings.

20 Each preliminary and detailed drawing is comprised of vector
21 elements typically created and placed using an input device, such as a digitizer
22 manipulated by a draftsman. For minimizing the labor involved in repetitively
23 drawing consistent and known shapes, the elements themselves are usually

1 provided as part of a predefined block or symbol or as a plug-in application provided
2 with the CAD program. A draftsman is still required to review the specification,
3 choose the appropriate element and properly position the element in accordance
4 with the known specifications and the individual professional's experience.

5 Further, individual clients or draftsmen are expected to distinguish
6 a room from a corridor, and then define which of the various types of rooms receive
7 which level of services (e.g. dedicated electrical outlets) and how the service will be
8 supplied (e.g. through the floor or from the ceiling).

9 This known process, preliminary drawing through to detailed drawing,
10 is laborious and inflexible. It is inevitable that there will be changes in the overall
11 design which arise during the usually protracted duration between obtaining the
12 preliminary drawings and final issuance of the detailed drawings. Further, the
13 resulting level and quality of the details in the design is variable due to many levels
14 of design input, from the design professional to the draftsmen. There is a need
15 to repeatedly and dynamically revise each drawing, in a domino effect, for changes
16 which arise in one or more related drawings.

17 About one half of the time expended, between obtaining the
18 preliminary drawings and issuance of the detailed design drawings, is consumed in
19 the detailed drafting portion. This creates two main disadvantages: a significant
20 time delay, and a related increase in cost.

21 Further, while an architect, design professional or other client is
22 constrained by many known and standardized codes, there are also instances
23 where the known codes are inapplicable and personal judgment is applied or where

1 the client's or design professional's personal standards exceed those of the codes.
2 Each time the design process is commissioned, those personal and professional
3 judgments or standards must be communicated to and be known by the
4 draftsman, generally through a working relationship developed over time, so that
5 that appropriate standards and codes are utilized. Often the draftsman simply
6 adopts a number of personal and professional judgments or standards that are
7 known, or which are assumed to be preferred by the design professional and those
8 become the rules which are applied to the detailed design drawings.

9 Accordingly, there is identified a need for a system to aid the design
10 professional, clients and client-engineers who wish to improve the detailed design
11 process including to achieve the following: reduced turnaround, reduced costs,
12 repeatedly and reliably applied personalized standards, and reduced overhead on
13 the design professional where professional and standard codes are known and
14 where individual professional standards can be learned and applied.

15 16 SUMMARY OF THE INVENTION

17 The present invention is a process for automating the determination of
18 detailed engineering specifications and production of detailed engineering CAD
19 drawings from a client's raw architectural drawings. Architectural drawings are not
20 generally sufficiently detailed for one to develop a cost estimate, to direct the
21 actions of a construction contractor, nor to establish compliance with mechanical
22 and electrical standards, to name a few. Not only does an architectural drawing
23 comprises a multitude of drawings elements but it also comprises assets formed of

such drawings elements including corridors, rooms and utility rooms, all of which have different requirements for electrical and mechanical services, standards and compliance.

An architectural asset is more than merely geometrical characteristics such as a bounded area, or line dimension. Architectural assets also have functional characteristics. For example, two rooms having the same lineal wall length or area can have vastly different engineering specifications – for example compare a like-sized machine shop and a gymnasium. The number of choices necessary to assign the proper services and detail to an architectural drawing can be enormous. Such a task is normally indeterminate and requires repeated involvement of a design professional to bridge the gaps in most building standards.

The current system leads a client through a novel process of providing an architectural drawing, in a digital format, containing an architectural structure, parsing the drawing to locate the structure's determinative assets, applying standards applicable to at least the functional characteristics of the assets, and generating the detailed features necessary for production of detailed engineered drawings. Throughout, the client is encouraged to impose their professional and individual preferences on the design, these preferences being noted for future and repeated use. Defaults are provided which the client can override, including the clients own previous preferences. This is an ongoing learning process. Each project adds to the client's known professional preferences, ultimately resulting in a process requiring little or no additional intervention for subsequent projects, while still resulting in detailed designs that conforms to the client's personal and

1 professional expectations. Moreover, by relying on a set of default standards, the
2 system is sufficiently flexible and advantageous so that, in some instances, if a
3 client wishes to obtain a quick and rough cost estimate, the system has the ability to
4 generate detailed engineering drawings in a single pass through the process, with
5 minimal intervention by the client.

6 Accordingly, the present invention accepts a client's preliminary
7 architectural drawings and automates the production of detailed engineering
8 drawings, specifications and reports which are sufficiently detailed for establishing
9 compliance with known criteria. In a broad aspect, this process comprises the steps
10 of:

- 11 • reading one or more CAD files containing at least drawing
12 elements forming one or more architectural assets;
- 13 • parsing and labeling the one or more assets found within the
14 one or more CAD files which have correspondence to labeled
15 assets stored in an architectural assets database, the assets
16 preferably being located in discrete drawing layers for ease of
17 parsing;
- 18 • retrieving compliance criteria from at least one compliance
19 criteria database in which are stored compliance criteria
20 corresponding to one or more of the labeled assets;
- 21 • retrieving preferred criteria from at least one preferred criteria
22 database in which are stored preferred criteria corresponding to
23 one or more of the labeled assets;
- 24 • applying the compliance and preferred criteria to the labeled
25 assets for establishing detailed engineering specifications;
- 26 • generating detailed drawing elements corresponding to the
27 detailed engineering specifications; and
- 28 • writing at least the generated detailed drawing elements, to one
29 or more output CAD files, and preferably also writing related
30 reports.

31
32 Preferably, a computer is provided having means for reading,
33 manipulating and writing CAD drawing elements and data files, and means for

1 storing databases and performing operations thereon. More preferably, the process
2 further comprises the steps of: maintaining an interactive network system and
3 having at least one client terminal; downloading the client's raw CAD files from the
4 client's terminal; and uploading detailed output CAD drawings to the client's
5 terminal. It is advantageous also to maintaining one or more preferred criteria
6 databases for the known client and then implementing a security and authentication
7 process which ensures that the client's preferred criteria databases are only
8 accessed by the known client.

9 The process is preferably recursive for enabling review of the detailed
10 drawing elements and modification of the preferred criteria prior to outputting a CAD
11 drawing and related reports.

12 These one or more databases are preferably located at the computer
13 performing the manipulation. The database of compliance criteria comprises at
14 least one database of general detailed design standards. The compliance database
15 can also include specific design standards such as those detailing electrical or
16 HVAC standards and default preferred criteria which exceed compliance criteria in
17 some instances or provided further criteria where compliance criteria is non-existent
18 or insufficiently detailed. The preferred criteria database comprises one or more
19 databases of system default criteria or client preferred criteria which adds to, or
20 exceeds the compliance criteria. Repeated use of the process by a client adds
21 additional preferred criteria to that already stored in the preferred criteria database,
22 eventually obviating a need for repeated interrogation by the system to fill in further
23 criteria.

1 The raw architectural CAD drawing file usually includes, or is
2 accompanied by, textual characteristics data so as to define a minimum number of
3 drawing elements, features and characteristics. For increased functionality, the
4 interactive network system provides a recursive interactive form which ensures a
5 minimum of drawing elements, data and criteria are provided with each CAD
6 drawing and process.

8 BRIEF DESCRIPTION OF THE DRAWINGS

9 Figure 1a is an overall schematic flow chart of the connectivity and
10 functions of the present invention;

11 Figure 1b is a flow chart of one process used in implementing the
12 present invention;

13 Figure 1c is a schematic illustrating a relationship between general,
14 specific and client preferred standards;

15 Figure 2a is a more detailed flow chart of an embodiment of the system
16 of Fig. 1b, detailing uploading of a preliminary CAD drawings and recursive checking
17 for a minimum required data necessary for processing;

18 Figure 2b is a flow chart of the system, continued from Fig. 2a, for
19 parsing a CAD drawing, determining its assets and the application of general,
20 specific and client criteria to add engineering features;

21 Figure 2c is a flow chart of the system, continued from Fig. 2b, for
22 accepting touchup modifications and generating detailed engineering output CAD
23 drawings and updating of the client preferences;

Figure 3 illustrates a raw architectural drawing which includes various defined drawing layers which aid in the recognition / parsing process; a portion of a text-version drawing exchange formatted (DXF) file illustrating a drawing element under the named layer WALL-INT;

Figure 4 illustrates one recognition / parsing process for determining assets, such as bounding walls in a raw architectural CAD drawing from a room ID label, these room ID's corresponding to assets EOFFICE and GOFFICE;

Figure 5 illustrates an interactive post-parsing form, including drop-down menus, for permitting changes to the default electrical specifications for the known structure and assets;

Figure 6 illustrates a portion of an interactive form, including drop-down menus, which incorporates compliance, default and preferred criteria for review and modification by the client;

Figure 7 is an exploded view of a resulting detailed electrical schedule which check boxes enabling addition or removal of the generated detailed features, complete with electrical load totals;

Figures 8a and 8b are raw architectural and output detailed electrical engineering CAD drawings for a portion of a school, using the criteria as set forth in Fig. 6;

Figure 9a is a portion of a plan view of an architectural drawing demonstrating the plan of a structure;

Figure 9b is a closer view of the lower left corner of the plan view of Fig. 9a;

Figure 10a is a portion of a plan view of the finished detailed electrical drawing of the lighting for the structure of Fig. 9a, said drawing in compliance with the General ES, Specific ES and Client ES applied thereto and output in a detailed design CAD file;

Figure 10b is a closer view of the lower left corner of the plan view of Fig. 10a;

Figure 11a is an example of the textual output reporting, in this case electrical specification annotations as applied to a detailed drawing accordingly to the General ES and Specific ES applied to the structure of Figs. 9a-9b;

Figure 11b is another example of the textual output reporting as applied to the structure of Figs. 9a-9b;

Figure 12a is an example of the textual output reporting, in this case annotations for mechanical specifications as applied to a detailed drawing accordingly to the General ES and Specific ES applied to the structure of Figs. 9a-9b;

Figure 12b is another example of the textual output reporting as applied to the structure of Figs. 9a-9b;

Figure 13a is a portion of a finished detailed electrical layout of a building and common area; and

Figure 13b is a portion of a finished detailed mechanical layout of the same building and common area as shown in Fig. 13a.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a design/drafting system for use by design professionals (also known as clients, users or client/engineers). The system is complementary to existing proprietary computer assisted drawing (CAD) software packages such as AutoCAD, from Autodesk Inc. of San Rafael, CA, or Micro-station from Intergraph of Huntsville, AL. Further, in a distributed network implementation, internet browser plug-in CAD-viewers can also be utilized, including InViso from Informative Graphics Corporation of Phoenix, AZ. Note that a client may not even need to own a licensed copy of expensive proprietary software to use the present invention; the client only needs to provide a compatible drawing such as that often provided to them by their architect who would be a licensed user.

In a preferred embodiment, the system accepts client input including raw CAD information in a digital format and, coupled with a rule-based process for applying standards, generates detailed engineering specifications and information. This embodiment is described in terms of the evolution from raw architectural drawings to completed engineering drawings ("detail drawings") and related information such as equipment schedules and bills of materials. However, it is understood that the principles described herein can also be applied in other disciplines in which such a process can be applied.

Having reference to the flow chart of Fig. 1a, a preferred system comprises several components: a client access terminal 10, such as a computer connected to a distributed network 11 such as the internet or intranet; and an application server 12. The server, and its application programming for practicing

1 the method of the invention, comprises computer processing means including digital
2 input and output means for receiving and writing/transmitting digital drawing
3 information. Further, the computer provides hardware and software processing
4 means capable of interpreting, reading and writing drawing information files,
5 including databases and CAD files. In this preferred embodiment, the computer is a
6 part of an internet network and more preferably as an internet server operating the
7 method of the invention as computer instructions and having data security capability
8 for providing administration control and further to provide the client with secure and
9 private access to the client's own profiles and other private information. Generally,
10 and in the context of an internet environment, the server provides an internet web
11 site for access by client terminals 10. The system enables a novel process as set
12 forth in Fig. 1b.

13 Having reference to Fig. 1b, the process comprises: initiation 20 of a
14 project by a client, the project defined by one or more raw architectural drawings
15 and information; identification of the client and their choice 30 of the appropriate
16 rules to apply to the project drawings; and validation and parsing 40 of the drawings
17 to discover client-defined assets and their characteristics. Recursive checking 50 is
18 applied for ensuring minimum required data is provided in the raw drawings. Next is
19 a processing step 60 for applying specified criteria and rules 70 and enable
20 generation of detailed specifications, drawings and reports 80. Generally,
21 application of specified criteria and rules 70 includes interpretation and
22 incorporation of engineering design standards into the drawing – both general
23 criteria which are generally absolute and static, and preferred criteria which are

1 variable or adjustable. Once the detailed specifications 80 are generated, final
2 revisions are performed 90 and detailed engineering drawings, reports and the
3 applied profile are delivered 100. The delivery step 100 includes output of detailed
4 design data, annotation of engineering features as drawing elements added those
5 provided in the raw architectural drawings and output of various reports, schedules,
6 specifications and final detailed drawings in the same client-compatible drawing
7 data formats originally provided at 20.

8 The means by which the client's project drawings are provided,
9 validated and delivered can vary widely. At 20, a client can provide digital media
10 containing the project drawings directly to the entity conducting the processing and
11 receive as digital media or hard copy blueprints as a deliverable 100. Preferably, a
12 distributed network of client computers and application servers are used for
13 obtaining 20 the raw drawings and providing deliverables 100 as set forth in greater
14 detail in Figs. 1a-1c and Figs. 2a-2c.

15 16 Specified Criteria and Rules

17 Referring to Fig. 1c in the processing step 60, the system applies rules
18 70 to the project in a hierarchy for determining the amount of detail necessary to
19 prepare detailed engineering drawings. Criteria is a form of rule applied to an
20 architectural asset. Such criteria include General Engineering Standards (General
21 ES) and Specific Engineering Standards (Specific ES) which augment and enhance
22 General ES. There can be multiples of each of the General ES and Specific ES, as
23 one can see that the standards applied to an office are not necessarily the same as

1 those applied to a school. Each office or architectural asset is more than merely
2 geometrical characteristics such as a bounded area, or a line dimension.
3 Architectural assets also have functional characteristics which affect the standards
4 applied thereto. For example, a machine shop requires vastly different electrical
5 services than does a gymnasium, even if they have the same floor area, and length
6 of bounding walls. An asset can be a photocopier having specific electrical and
7 ventilation requirements. An asset can be a room, or a collection of rooms, or even
8 a parking lot having electrical service requirements.

9 General ES include various regulatory codes and design elements
10 that are absolute and rarely change. For instance, the National Electrical Code
11 (NEC) in the United States and the Canadian Electrical Code (CEC) specify certain
12 minimum standards. The American Society of Heating, Refrigerating and Air-
13 Conditioning Engineers (ASHRAE) sets the standards of accepted practices for the
14 industry worldwide. The various standards and codes which establish minimum
15 standards for compliance and generally acceptable engineering practices form the
16 General ES. If the design professional should attempt to make a change to the
17 General ES that would fail to meet the minimum standard the design professional
18 will be provided with a warning of the violation of the applicable regulatory or
19 municipal code.

20 The General ES are not necessarily comprehensive and reliance
21 solely upon the General ES can result in an indeterminate solution. To make the
22 process determinate, the process itself or the design professional must be able to
23 impart acceptable professional standards and professional judgments, to this rule-

1 based system, that are individual to the design professional. In this case, it is only
 2 the design professional that can dictate what is acceptable.

3 The General ES provide the base standards which can be augmented
 4 by specific standards. Default specific standards (Default SES) are provided by the
 5 system. Generally an engineering advisory committee predetermines a number of
 6 default options, any of which may be acceptable as a standard, but where a choice
 7 must be made. The default choices are listed and published as part of a Specific
 8 ES so that a design professional may choose any of the available listed choices or
 9 make a different selection altogether. In the simplest case, should the design
 10 professional not alter any of the default choices, the detailed drawings are
 11 generated using the General ES and Default SES standards alone. For example,
 12 while a General ES may specify whether lighting is required in each room or the
 13 size of the electrical service, Specific ES are also provided to augment the General
 14 ES such as specifying whether the detailed lighting would be ceiling-mounted
 15 fluorescent lighting or if the next greater service should be provided to ensure it
 16 could meet potential increases in demand. Examples of applied Specific ES,
 17 comprising both Default SES and Client ES's are illustrated in Figs. 11a – 12b.

18 The client can provide their own Specific ES and override the Default
 19 SES to form one or more Client-specific ES (Client ES). Once the client has
 20 completed a first project, one or more Client ES's result. As modules are, by their
 21 nature, substantially repetitive work, there is an opportunity for clients to create
 22 significant efficiencies in their professional practices through the use of the system.

1 Each project is likely to result in more-and-more refined preferred criteria and form
2 the basis for more refined Client ES and multiple Client ES's.

3 General ES and Default SES and Client ES are stored in respective
4 General ES and Default SES and Client ES databases. A client can specify a
5 Specific ES, selected from Default SES or multiple archived Client ES's.

6 Application of the system is not limited by distance or jurisdictions
7 however, the applicable codes and standards, General ES and Default SES would
8 usually be developed for a particular jurisdiction. Multiple sets of General ES can
9 be provided, dependent upon the type of project. It is known that certain
10 engineering standards are used in repetitive applications in numerous buildings
11 constructed in each of the building jurisdictions in North America. These standards
12 are compiled into a plurality of module types. The modularization of building types
13 aids in the preparation of projects that are relatively small in comparison to industrial
14 engineering projects, where there are numerous hours expended and there is little
15 repetitive design/drafting functions. An example of such modules includes a school,
16 or an apartment/condo – electrical module and an apartment/condo – mechanical
17 module. Further, while North American standards are substantially the same, there
18 are differences; such as between the Canadian and US National electrical codes
19 (CEC, NEC). Preferably, modules are developed and provided for jurisdictions in
20 North America having the largest building volume, with preference to jurisdictions
21 where market analysis demonstrates a greater potential for use. Further variations
22 in standards are more readily provided within the Specific ES or Client ES.

1 The modularized approach allows the system to deal with a
2 manageable number of considerations and variables in preparing General ES and
3 Default SES for that module and further allows the client a manageable opportunity,
4 through the Client ES, to imprint on the General ES and Default SES the client's
5 own professional preferences. The client can browse the General ES for each
6 module enabling review of the applicable engineering standards and choices.

7 The General ES, Default SES and Client ES are applied to the raw
8 architectural drawings for generating engineering specifications and information
9 suitable for creating detailed drawings including mechanical and electrical drawings.
10 It is seen that the system generates drawings that not only reflect the professional
11 judgment of the client but will also output accurate drawings, delivered with a very
12 quick turn around time and which are very cost effective when compared to the
13 manual alternative for the preparation of drawings.

14 The Raw CAD Drawing

15 Referring to Fig. 2a, to provide a new project 20 a client uses the
16 terminal 10 and an internet web browser to log-in through the internet 11 and to the
17 web site on the server 12 which is secured and which requires the client to provide
18 a username and password combination to assure authorized access. After log-in,
19 the server 12 initiates an application program which identifies the client and
20 retrieves one or more stored known client profiles 30. A client profile can include
21 their identity, their billing arrangement, and last project information such as the last
22 drawings, module or Client ES databases used.
23

The server 12 displays a menu of hyperlinks. While the possible display options are virtually unlimited, the hyperlinks typically include functional equivalents to “work on a new project”, “retrieve / edit an existing project”, “profile configuration”, “download needed software”, among others. Upon clicking a hyperlink so as to choose new project, the client’s profile is invoked and directory listings, along with some basic file management functions and directory navigation options, are presented in the browser screen, typically listing a client’s drawing files and folders that are present on the server.

A client can choose a project which can include one or more drawings. Such project files may already be stored on the server 12, or can be uploaded to the server. The client must choose or upload one or more raw architectural CAD drawing files and other associated data as necessary and in a format compatible with formats supported by the server’s applications programming. Herein, unless the context suggests otherwise, the term “CAD drawing” or “drawing” includes associated text and other data annotated thereon or provided in separate files.

In a simple embodiment, the client provides raw architectural data and supplementary information in a compatible format including that provided in a CAD file. Such means can include suitable storage media containing the necessary information or that provided via an internet network system. A suitable CAD file includes those compatible with AutoCAD *.DWG format which can include both vector graphics, which define the architectural elements, and textual elements, which can define supplemental information such as ceiling height. Optionally, supplemental data is provided in a separate digital file. Once uploaded the file or

1 files appear in the client's directory. To process a preliminary architectural CAD
2 drawing the client selects the appropriate file in the directory (by clicking on an
3 adjacent radio button) and then clicks on a process button.

4 As a default the server will select a previous client profile, or
5 determine the profile from the nature of the CAD file. Otherwise, the client chooses
6 a profile and a module to apply to this drawing; the module being specific to
7 jurisdiction and the type of structure. These issues determine which criteria are
8 imposed upon the design and which affect the ultimate detailed engineering
9 drawings and reports. Once a module is selected, default choices are provided.

10 The design professional then either accepts or overrides the General ES and
11 Default SES or overwrites some or all of those standards with their own Client ES
12 which the client wishes to embrace for projects within the module type. These
13 modification and instructions are variable from project to project and reflect the
14 special needs of an end user of the building, or of the design professional, arising
15 out of the performance requirements of the project upon completion and thereafter.
16 Interactive and formatted reference forms facilitate the creation of the design
17 professional's Specific ES. Mandatory field response requirements aid in assuring
18 all the necessary design data is obtained. Once completed, the resulting modified
19 Client ES can be archived on the server 12. Those Client ES are proprietary to the
20 client, password protected and stored for future and repeated use by the design
21 professional for reuse on subsequent and similar projects.

22

Filtering - Confirm Minimum Data

Still referring to Fig. 2a, the process assesses if the CAD drawing has the minimum necessary data, structures and assets necessary for interpretation of the drawing. This assessment can simply include a rudimentary filtering to confirm that the drawing and information is in a compatible format or could be as much as a full parsing of the drawing described in greater detail below. If insufficient information is provided, then an interactive dialogue between the server's application program and the client ensues to correct the client's formatting of the drawings. In early sessions, it may be necessary to further involve the server's professional staff. Various interfaces are provided for ensuring that enough information has been provided by the client. Primary interfaces include forms having fields which must be filled in before submission and mid-processing interfaces which request additional data. The format of the forms is dictated by the module and the various ES's.

The results of this interaction are incorporated into the client profile and resulting Client ES so as to minimize need to revisit these questions in the future. The input data is tested against a minimum checklist and further processing is not conducted until the minimum number of elements is provided. Further, the filter ensures that the format of the file can be reliably interpreted. Such formatting includes specifying which of the CAD drawing's many layers, such as floor plans, sections and elevations, contain the expected electrical appliances or building elements, including but not limited to doors, windows, interior and exterior walls,

1 ceilings, cavities, structure, ceiling materials, ceiling heights, and materials
2 insulation factors.

3

4 Parsing the Drawing

5 Referring to Figs. 2b and 3-5, a parsing or recognition process is
6 performed on the architectural drawings for interpreting and determining major or
7 key structures or assets of the architectural design. The system reads the known
8 data format for the CAD file and extracts the assets. As stated earlier, one well
9 known and published format is the AutoCAD native drawing file format DWG.
10 Another format is a Drawing Interchange File DXF. Use of the native DWG format
11 is discouraged due to the variability of its organization from version to version. The
12 overall organization of a DXF file is typically as follows: a HEADER section
13 containing general information about the drawing including an AutoCAD database
14 version number; a CLASSES section holding information for application-defined
15 classes, whose instances appear in the BLOCKS, ENTITIES, and OBJECTS
16 sections of the database defined hereafter; a TABLES section containing definitions
17 for various symbol tables (not described herein); a BLOCKS section containing
18 block definition and drawing entities that make up each block reference in the
19 drawing; an ENTITIES section containing the graphical objects (entities or
20 elements) in the drawing such as a vector from X1,Y1,Z1 to X2,Y2,Z2; and lastly for
21 the descriptive purposes herein, an OBJECTS section containing non-graphical
22 objects in the drawing such as text and dictionaries of the line styles.

1 The system interprets the raw architectural data for assessing the
2 layout of the structure from a combination of drawing elements including numbers of
3 rooms and floors, locations of windows, doors and stairways. Limitations in some
4 recognition algorithms may require the entities or drawing blocks to be closed to be
5 recognized, as discontinuous endpoints are problematic.

6 Referring also to Fig. 3, a typical drawing comprises layers, each layer
7 storing related drawing elements. The illustrated sample drawing is displayed in an
8 AutoCAD program with a drop-down menu function selected for displaying the
9 named layers. In the example drawing, all elements defining internal walls are
10 located in the layer named WALL-INT. This format of placing known assets in
11 named layers assists in parsing assets, such identifying in which layer electrical
12 plugs could be located. In another layer PRINTERS, all entities representing
13 computer printers are located, providing the means to determine the lengths and
14 need for data cabling and power. A room identification layer RM-ID is provided for
15 indicating the type or purpose of each identified asset (e.g. a device, a room, a
16 collection of rooms); whether it be a heavy industrial shop area which requires
17 special and higher amperage electrical outlets, or an office requiring multiple low
18 amperage outlets and additional data cabling.

19 Using comparative examination techniques and the predetermined
20 formatted input data, the system parses the drawing, recognizing, labeling and
21 storing the labeled key building assets in an architectural assets database.

22 Turning to Fig. 4, for example, a preferred recognition process is
23 illustrated in which the coordinates of the RM-ID are located. The bounding walls

are located and the area of the room is determined. One preferred approach is to search radially in the WALL-INT layer for bounding internal walls. Where a discontinuity exists, the center of the radial search can be incrementally moved to another location so as to determine if the discontinuity is an open passage, or a drawing error.

Assets recognized in the parsing step will correspond to known assets stored in the architectural assets database, otherwise design criteria and rules cannot be applied. For instance, in this example, the client must advise in the initial data or Client ES that both the principle's and vice-principal's offices are equivalent to a stored database asset EOFFICE, for which certain common Specific ES criteria or Client ES and rules can be applied. Either the client can conform to the format required by the server's application program (which layer contains which information) or the client's profile could contain information to enable mapping of their proprietary format to the application programs requirements.

Having reference to Fig. 5 and in a review step, once all the necessary formatting is provided, the raw drawing is parsed and the client is presented with another interactive form displaying the recognized assets. This is an opportunity for the client to amend and revise the criteria which has been applied to the assets. As shown, the filter step applies the client's last Client ES, or a Default SES for making a preliminary assessment of the assets contained in the drawings. The application program can apply such preliminary defaults upon determining that assets include "CLASSROOMS" = a school, or an asset "LIVING ROOM" = apartment/condo. Accordingly, a first form is provided so that the client can override the Default SES's

choice of the default type of electrical outlets, the number of outlets, and the rating of these outlets for each asset or room in the preliminary CAD drawing. Using an electrical example, Fig. 5 further illustrates use of a table format for quick and easy review by the client, with the asset tabulated against a drop-down menu of the particular standard applied, and the outlet type (such as between duplex, split, half-switched, etc).

Apply Standards

As shown in Fig. 6, with the minimum requirements having been met, a second interactive form provides an expandable configuration tree or list where the client can vary or adjust the applied General ES, and Default SES rules. In the electrical example as shown, one enters project specific and preferred data in the text boxes, by selecting from drop down menus or by selecting, via radio buttons, the rules that pertain to the project. For example, clicking on the + expand symbol next to the "Corridors" heading reveals more detailed rules - such as those allowing the client to specify how far the electrical outlets are spaced apart and the amperage rating of these outlets. Once expanded, the + symbol next to the heading changes to a – symbol, which, when clicked, collapses that part of the configuration tree. Many other headings are included in the configuration tree, each independently expandable / collapsible and each allowing the client to make changes to the default rules and settings.

Once the client is satisfied that the parameters and rules are properly set, the form and its settings are posted to the web server by clicking the "submit"

1 button on the bottom of the form. When the information in the form is received by
2 the server, an application program at the server generates detailed features
3 according to the criteria set by the General ES, Default SES, individual Specific ES,
4 and Client ES as modified by the form.

5 Further, the application program can apply the detailed features to
6 generate a detailed CAD drawing from the preliminary architectural CAD drawing.
7 Such modification includes adding drawing elements to the CAD drawing which
8 represent lighting, electrical outlets and mechanical components. One method for
9 reviewing the results includes opening a new browser window which, using an
10 appropriate third-party plug-in, displays a visual preview of the modified CAD
11 drawings and schedules. The client can then inspect any part of the preview and
12 determine the design was performed as expected.

13 Upon previewing the output drawing file, the client may determine that
14 revisions to rules and the drawing are required.

15 Having reference to Fig. 7, the original browser window is refreshed
16 and now contains another form. The form can be a schedule in table format listing
17 each of the detailed features or additions made to the raw CAD drawing, together
18 with their accompanying information. For example, each of the resulting electrical
19 outlets are all given a unique and incremental identifier, and their location on the
20 CAD drawing is identified by x, y and z co-ordinates. The client is able to remove
21 any one or all of the electrical outlets by clicking on an adjacent check-box button
22 which is in the "remove" column in the far right of the table. Information for the
23 resulting electrical panels is then displayed in a second table underneath the first

1 schedule. Again, each panel is labeled, and the total of the electrical loads are
2 summarized at the bottom of that table.

3 When the client is satisfied that all the detailed features, such as all
4 the electrical outlets, are satisfactory and that any that are to be removed have the
5 check-boxes highlighted, then this form is posted to the server by clicking the
6 “continue” button. When the information in the second form is received by the
7 server, the server will modify the CAD drawing, if necessary, removing any of the
8 additions selected with the check-boxes.

9 Another new browser window pops up displaying a visual preview of
10 the finalized CAD drawing.

11 12 Processing – Deliverables

13 Having reference to Figs. 2c and 8a,8b, deliverables or output
14 comprises detailed engineering specifications in a format including both detailed
15 drawings and specialized reports, such as specification schedules, mechanical
16 schedules and bills of materials. Other output and reports can include shop
17 drawings, catalog cuts, operation and maintenance manuals, details regarding
18 insurance compliance and requirements, published design reports, tabulated
19 charts/values/quantities, and Underwriters Laboratories (UL) set /assemblies. For
20 the drawings, the mechanical and electrical details are rendered in the appropriate
21 client's preferred CAD format to create the one or more required mechanical CAD
22 drawings, electrical CAD drawings, any annotations and associated reports.

1 Having reference to Figs. 8a and 8b, a raw architectural drawing is
2 shown (Fig. 8a) and a detailed electrical output drawing resulting from the present
3 invention is also shown (Fig. 8b), complete with annotation and unique identifiers for
4 each electrical outlet. Such unique identifiers can be used by the contractor in
5 physically labeling and tracking the electrical outlets.

6 The original browser window is refreshed and then contains an option
7 to save the finalized CAD drawing or drawings. A request is made to assign a
8 name for the drawing or drawings in the project. By entering a file name, and
9 clicking the "save" button, the server saves a copy of the finalized CAD drawing.
10 Any adjustments which were made to the preferences can also be saved to the
11 current client profile, to a new named profile, to a current Client ES, or to a new
12 Client ES. The client is provided with file management functions and directory
13 navigation options as before; including the ability to download the newly created
14 CAD drawing from the server.

15 Additional examples of architectural CAD drawings and detailed
16 output CAD drawings are shown in Figs. 9a-10b and in Figs. 13a and 13b. The
17 output files illustrated in Figs. 10a and 10b illustrate comprehensive detailed
18 engineering specifications including lighting. Fig. 13a illustrates output detailed
19 electrical specifications including annotations such as an electrical legend. Fig. 13b
20 illustrates a CAD drawing with added detailed mechanical specifications.

Example of the Hierarchy of Standards

One example of a design professional or engineering-client is a specific project engineer who is approved to utilize the system of the present invention on behalf of a third party. Alternatively, the engineer uses the system for their own projects, such as for a chain of similar facilities – such as gasoline stations. The client's organization would retain one or more Client ES databases from past projects. The Client ES includes the specific choices made including those from the General ES and Default SES. On the other hand the client may choose to have each project engineer use their own individual Client ES's for the same raw architectural CAD drawing as individual preferences tend to vary from engineer to engineer. In cases of an in-house design of repetitive facilities, Client ES information can also come from non-engineering personal where they relate more so to qualitative and value choices, rather than to code or Specific ES issues.

In other cases, the client is often a building or project owner. In such situations an architect usually represents the client and has input to the preferred parameters. A client could also be a school division, in which case certain broad concepts and parameters would be inputted to the system from information given from the senior maintenance official or design criteria team leader from the school division. Other more specific information would be obtained from the architect hired by the school division. This information would be tempered by the desires of the school board, but would provide specific direction regarding quality, aesthetics and performance of the systems being engineered.

As stated previously, the standards are rules or set instructions assembled in the system that are referenced in the process of expediting a project or portion thereof. Rules fall into two categories. An absolute rule is one that is neither adjustable nor modifiable to suit the specific project or client need. These rules for the most part are located in the General ES and include minimum code standards, or are widely accepted General ES that are fixed. In some cases, where the absolute rule is made up in part of a variable (e.g. a number, value, yes/no decision). These rules are stored in Default SES or Client ES databases. The system permits adjustment or modification of these Default SES or Client ES rules, however, the systems clearly notifies the client that this rule has been changed.

The second category of standards is adjustable rules. These rules are modifiable to suit the needs or desires of the client and have default settings or values which can be modified or adjusted.

The following are examples in an electrical engineering context. Other applications include architectural, municipal planning, infrastructure, structural and mechanical.

An absolute General ES rule could be:

- Lighting fixtures recessed in fire rated ceilings must be fire rated themselves or have a drywall enclosed fire rated box put over them.

Or

- Ceiling mounted lighting fixtures cannot be lower than 6'6" above the floor unless they are vandal proof or have a wireguard.

Alternatively a Default SES adjustable rule could be as follows:

- 1 • Where recessed T-bar ceiling mounted lighting fixtures are placed
2 in a room, they are to be located as evenly distributed as possible,
3 while still following the T-bar pattern.
4

5 A Default SES or client specific Client ES variation to this rule on a
6 specific project with abnormal amounts of exterior glass might be:

- 7 • Where recessed T-bar ceiling mounted lighting fixtures are placed
8 in a room, they are to be located as evenly distributed as possible,
9 while still following the T-bar pattern. Assume the exterior 4' of the
10 room along glazed walls is not part of the room for lighting
11 purposes.
12

13 The General ES database outlines the specific applicable codes to be
14 used on the specific project. It will allow for interaction by the client to input local
15 jurisdictional changes to suit specific county or municipality regulations. State wide,
16 Province wide and municipal codes are available as "default" choices.

17 The absolute rules of various codes are imbedded into the system and
18 can be adjusted only where numerical values are part of the code, and then only if
19 the client is reminded that these values do not comply with codes. The reason to
20 allow variability in values is to allow the client to determine the effect of adjusting the
21 code values. There are times when an client or end user are concerned about a
22 specific code or building regulation causing extra capital cost or operating expense.
23 Depending on the result, the client or end user may try to have the space utilization
24 renamed, or relaxation from local authorities. A good example of this is the need for
25 ventilation in shops for welding. Depending on the duration and extent of ventilation
26 costs can change dramatically. In most jurisdictions, however, if a shop is called a
27 "welding" shop instead of a "machine" shop the ventilation requirements change.

28 An example of codes implemented in a General ES includes:

- 1 - Electrical Code (local jurisdiction),
- 2 - ASHRAE Standards,
- 3 - NFPA, and
- 4 - Building Code (local jurisdiction).

5 In addition to the General ES, a client's Client ES is provided. The
6 Client ES is a fixed record of the summary of rules used in expediting the project
7 and is stored as a reference for future projects by the same client. A client can
8 import the General ES data into their Client ES, or through interaction with the
9 system, so that the bulk of the General ES, Default SES and Client ES for an old
10 project can be applied to a new project and yet are also modifiable to suit the new
11 project.

12 General ES's include those engineering practices that are widely
13 accepted across the industry. These are practices, choices and value decisions
14 that rarely change, no matter what the location, project or who end user is. The
15 General ES database is modifiable by the client and can be reused from project to
16 project.

17 The General ES data form as it relates to the sizing of power feeders
18 to electrical panelboards may appear as follows:

- 19 Rules for sizing electrical feeders to panelboards:
- 20 1. Where calculated load is less than or equal to 80 amps, use 100
 - 21 amp feeder, except for 3 below.
 - 22 2. Where calculated load is above 80 amps, but less than 160 amps
 - 23 use 200 Amp feeder, except for 3 below.
 - 24 3. Where a feeder is greater than 100' in length it should be sized at
 - 25 20% above calculated load plus voltage drop considerations.
 - 26 Note: Conduit and wire feeders are available at many sizes between
 - 27 100 plus 200 amps however; there is little or no economy in using an odd size due
 - 28 to the way materials are priced.
 - 29

The Specific ES are engineering practices that are commonly variable from client to client and area to area because of their personal preference. These practices are based on choices, value decisions and engineering/construction methods that can vary widely. The Specific ES database is modifiable by the client and can be reused from project to project. The client can assemble a series of Specific ES's to be used on a variety of projects, depending on the end user, location, type of project, budget, etc.

A good example of Specific ES is standard for the number of electrical outlets on a particular 120 volt circuit. The Canadian Electrical Code states no more than 12 outlets permitted. Rarely do 12 go on a circuit, except in residential design.

General ES would call for 6-8 outlets per circuit for average use in most buildings. This "rule of thumb" is inadequate because a machine shop will have outlets in offices, work benches, outside for maintenance etc, all for different purposes. The Specific ES clarifies all of this.

For example:

1. Specific ES rules for circuiting receptacles.

1.1 Office area 6 outlets per circuit, except for specific loads labeled.

- 1.1.1 Xerox,
 - 1.1.2 Printer,
 - 1.1.3 Car plug in,
 - 1.1.4 GFI outlet in washroom,
 - 1.1.5 Fridge,
 - 1.1.6 Microwave,
 - 1.1.7 Coffee Maker, and
 - 1.1.8 Counter top Receptacle other than 5, 6, or 7 above
- to be 2P.15A spit feed outlet.

1.2 Shop Area:

1.2.1 Columns - 2 receptacles per circuit, alternate circuits so no two receptacles are adjacent on same circuit.

1.2.2 Work benches; 2 receptacles per circuit; alternate so same circuit not adjacent.

1.2.3 Four-plex outlets on drop cords get two circuits per 4-plex. Use 2P.15A receptacle.

Specific ES's variable design criteria are project specific and would

ideally come from archived design criteria which was used specifically by the client

on previous projects to expedite a project or portion thereof. Such information often

involves value judgments, safety factors and margins of error type of qualitative

choices. An example of a Specific ES as it relates to the lighting of a 12' x 10' office

might have the following:

1.1 Lighting levels - Minimum 60 footcandles,

1.2 Energy Conservation - Less than 2W/square feet,

1.3 Choose minimum number of fixtures, maximum 4 lamps each,

1.4 Maximum 1200 W/circuit @ 120/208V, 3000 W per circuit @ 347

Volt, and

1.5 One circuit per room except where two level switched or more than limits in 1.4.

Preferred parameters in a Client ES are used by the specific project to

adjust the rules used by the system in expediting a project, or portion thereof.

These parameters are primarily made up of choices made by the client, rather than

technical engineering issues. An example of preferred parameters under a Client

ES would include:

Project: ABC School

Client: DEF School Board

Location: MetroCity, USA

1.1 Lighting Requirements:

1.1.1 Lighting Levels:

1.1.1.1 IES Standards (IES specifies lighting levels for every type of room or space and is widely accepted in the world.)

1.1.2 Other (if other is chosen a drop down menu of tables and choices will allow the selection of any lighting level for any space, provided it is within code allowed standards).

1.2 Lighting Types:

1.2.1 Exterior:

1.2.1.1 Post Top

1.2.1.2 On building

1.2.1.3 Landscape

1.2.1.4 Other (drop down menu of choices not usually or frequency used.)

1.2.2 Classrooms:

1.2.2.1 Fluorescent direct recessed T-bar

1.2.2.2 Fluorescent indirect

1.2.2.3 Fluorescent direct (surface)

1.3 Lighting Color:

1.3.1 Cool white Fluorescent

1.3.2 Warm White Fluorescent

1.3.3 Daylight

1.3.4 Other

1.4 Auxiliary Requirements:

1.4.1 Duplex Receptacles:

1.4.1.1 Four per classroom

1.4.1.2 50' on center in halls

1.4.1.3 Twenty-four feet on center in gym.

1.4.1.4 Etc.

1.4.2 Intercom outlets

1.4.2.1 One per classroom

1.4.2.2 One per teacher's workstation

1.4.2.3 Etc.

Note: If 1.4.2.1 were to be selected, a menu would appear that asks if the intercom outlet is at the teacher's desk, or adjacent to the door to the classroom. These types of prompts and clarifications prompt the responses needed for the forms to be completed.

Careful attention is paid to the development and format of the formatted interaction to ensure that the user is able to easily understand the issues and areas where professional judgment and preference may be exercised and that

1 as little of the valuable time of the design professional as possible is used in
2 applying the client's preferences.

3 One or more Specific ES are provided for each module type and are
4 cross-referenced with and attached to the General ES for that module type.

5 A simple example of the data which can be provided by the General
6 ES, Default SES and Client ES respectively is demonstrated in the following
7 challenge to calculate and choose locations for lighting in a 10' x 12' office.

8 In determining the parameters for the lighting of the 10' x 12' room, the
9 default choices may be presented as follows:

- 10 1 Fluorescent
11 b Glare Free
12 i Direct Downlight (deep cell parabolic)
13

14 The choices based on the needs and wants of the end user. The
15 client may make these choices and selections without consulting the end user,
16 based on experience and for knowledge of the project needs.

17 The above choices may have resulted from the following choices for
18 the type of lighting:

- 19 1. Fluorescent
20 2. Metal Halide
21 3. Pot Lights
22 4. Other (more choices and prompts are offered if this is chosen).
23 Client Chooses #1 "Fluorescent".

24 Choices are then offered of:

- 25 a. Standard fluorescent
26 b. Glare free
27 c. Other (more choices and prompts are offered if this is chosen)
28 Client Chooses #b "Glare free".
29

30 Choices are then offered as follows:

- 1 i. Direct downlight (deep cell parabolic)
2 ii. Direct downlight (Holograph lenses)
3 iii. Direct downlight
4 iv Other (more choices and prompts are offered if this is the choice)
5 Client Chooses #i "Direct Downlight (deep cell parabolic)".
6

7 The parameters chosen then were the same as the default stated
8 above as 1(b)(i).

9 More generally, the data preferred and modified by the client could
10 include:

11 General ES) Code

- 12 - Minimum 5 footcandles lighting
13 - Lighting minimum 6'6" above finished floor
14 - Standard wiring methods (non hazardous)
15 - Maximum 2 watts per square foot power consumption (assume this
16 is in a jurisdiction where energy use is regulated).

17 Default SES) DRF

- 18 - Provide 60 FC of lighting
19 - Use 2' x 4' lighting fixtures
20 - Use F32 T8 lamps
21 - Use 3000K lamps
22 - Calculate lighting level using default lighting calculations software.

23 Client ES) PRF

- 24 - Use fluorescent lighting
25 - Provide non-glare lighting

26 The system applies the rules and preferred standards and calculates
27 the number of fluorescent tubes to provide 60 footcandles of lighting. In this
28 example, the system calculates that nine F32 T8 lamps are required and searches
29 its rules to decide how to layout the room. Choices available in the rules are four 2'
30 x 4' fixtures @ 2 lamps each, three 2' x 4' fixtures @ 3 lamps each. The rules allow
31 these choices because the SEP for this client allows for 20% variance in the
32 number of lamps in rooms below 200 square feet. The system then calculates
33 specific lighting levels including minimum and maximum levels in all parts of the

1 room and determines the 4.2L 2XX fixtures is an optimal best solution, completing
2 the design of lighting in this 10' x 12' office.

3 The drawing production output process takes the design generated
4 and produces a graphic representation of the building engineering requirements. In
5 the example of the lighting design for a 10' x 12' office, the system interacts with the
6 data given (i.e.: 4.2'x 4' 2L F32 T8 fixtures in the room) and chooses an optimum
7 layout that fits within the T-bar grid. A graphic layout is then generated that
8 represents these choices using a CAD format of the client's choice. The client is
9 not required to interact at all with the CAD output generation in order for the
10 drawings to be produced.

11 Additional reports can be generated, all of which can be guided by the
12 user. During the process, or separately, the client can specify their preferences or
13 fill out and retrieve forms like specification data sheets which instruct the system
14 what to generate as Default SES or specifications for the project. Additional
15 sources of design information include catalog cuts and the like. The system
16 accesses relevant databases, interacts with the Specific ES data sheet to generate
17 these specifications. A predetermined report data sheet instructs the system what
18 to generate as reports for the project. Further, specialized instructions in drawing
19 plots are provided recognizing that each client or end user has specific line widths,
20 pen sizes and configuration of layers that they require for the plotting of drawings to
21 suit their own drawing standards. The system can have a library of drawing
22 standards to suit major clients. The client can select any of these, or create his own
23 custom file.